(51) International Patent Classification ⁶ :		(11) International Publication Number:	**WO 99/31937**
H04R 29/00	**A1**	(43) International Publication Date:	24 June 1999 (24.06.99)

(21) International Application Number: PCT/US98/25950

(22) International Filing Date: 7 December 1998 (07.12.98)

(30) Priority Data:
60/068,141   12 December 1997 (12.12.97)   US

(71) Applicant (for all designated States except US): KNOWLES ELECTRONICS, INC. [US/US]; 1151 Maplewood Drive, Itasca, IL 60143 (US).

(72) Inventor; and
(75) Inventor/Applicant (for US only): GARRETT, Regnald, G. [US/US]; 138 Circle Ridge Drive, Burr Ridge, IL 60521 (US).

(74) Agents: MORNEAULT, Monique, A. et al.; Wallenstein & Wagner, Ltd., 311 South Wacker Drive – 5300, Chicago, IL 60606 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: AUTOMATIC SYSTEM FOR OPTIMIZING HEARING AID ADJUSTMENTS

(57) Abstract

A system for optimizing hearing aid adjustments is disclosed. The system includes a computer (10). Speech material consisting of nonsense sentences or unrelated words from a word list is provided (12). The words are rich in frequency content and replete with time and amplitude variations. The speech material is presented aurally by a computer system (10) to a hearing impaired individual wearing an electronically adjustable hearing aid (14). The individual repeats the words, and the computer system (10) compares the repeated words to the original speech material and identifies the incorrect words in an error file. The system considers the incorrectly identified words and uses pre-knowledge of their frequency content and their time and amplitude variations to calculate an imputed inverse transform for a digital (DSP) aid.

AUTOMATIC SYSTEM FOR OPTIMIZING
HEARING AID ADJUSTMENTS

DESCRIPTION

Technical Field

The present application relates to hearing aids having adjustable frequency response characteristics, and more particularly, to a system which optimizes the frequency response characteristics of a hearing aid for a particular user.

Background Of The Invention

The hearing threshold of an individual is measured by one skilled in the art, typically an audiologist, using a variety of sounds, including pure tones and warble tones, and an audiometer. The result is displayed in an audiogram to show the difference in the hearing threshold for the individual and that of a normal hearing listener at 6 to 8 audio frequencies provided by the audiometer. Additional information is collected to characterize the sensitivity of the individual to loud sounds. This combined information is a measure of the individual's dynamic range of hearing.

Various protocols or formulas (such as the Half Gain rule, NAL, and POGO) have been used to define the desired hearing aid performance that would best serve the impaired individual. The hearing aid(s) that most closely matches the desired performance are then selected by the dispenser. In the fitting step, the dispenser fine tunes the adjustable features in the hearing aid to achieve the best match to the desired performance.

In recent years, the perceived loudness of sounds within the dynamic range is also measured, and new protocols, such as IHAFF and FIG6, have been developed to provide the dispenser guidance on the selection and adjustment of compression aids.

It is common practice for the dispenser to read a list, or to use a recorded list, of words to the hearing impaired individual, with and without the hearing aid, to determine the improvement in hearing with the aid.

The prior art hearing aid fitting adjustment procedure can be quite long and tedious, and its accuracy is limited because it is only guided by the fitting protocols and the experience/training of the dispenser to interpret the results of the work list test. While hearing loss has some typical patterns addressed by the fitting protocols, hearing loss is a highly specific condition that varies greatly from one individual to another such that the fitting protocols are not very accurate. As hearing aid technology has advanced with programmable and digital hearing aids, the range and number of parameters that can be electronically adjusted have increased. Fitting protocols have not developed as rapidly as hearing aid technology, and the fitting time has increased significantly, leading to sub-optimized performance.

Summary Of The Invention

The present invention is directed to a computer system method an apparatus for optimizing and automating the fitting of hearing aids based on speech material (not tones) as the input source to measure the performance of the individual using the aid.

Other features and advantages of the invention will be apparent from the following specification taken in conjunction with the following drawings.

Brief Description Of The Drawings

Figure 1 illustrate a flow diagram of the overall fitting process of the present invention;

Figure 1A illustrates a more detailed flow diagram for the determination of an imputed inverse transform, as used in the fitting process of Figure 1;

Figure 1B illustrates a more detailed flow diagram of the optimization process as used in the fitting process of Figure 1;

Figure 2 illustrates a hearing impaired individual training the speech recognition engine (SRE) to learn to recognize words dictated by the individual as read from the SRE computer monitor;

Figure 3 illustrates the hearing impaired individual with relevant hardware arrangement; and

Figure 4 illustrates a count of words in an error list as the optimization process proceeds.

Detailed Description Of The Preferred Embodiment

While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and will herein be described in detail a preferred embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the broad aspect of the invention to the embodiment illustrated.

The overall fitting process begins by having a hearing impaired subject train a voice/speech recognition engine (SRE) computer to recognize words as read from a visual presentation by the SRE on a computer monitor training screen. Subsequently, the dispenser fits a programmable hearing aid on the hearing impaired subject and connects the hearing aid to the program adjust module, such as Noah, which is also resident in the computer.

A computer system 10 for optimizing and automating the fitting of hearing aids based on speech material (not tones) as an input source to measure performance of a hearing impaired individual using the hearing aid is illustrated in Figure 3. The computer system includes, as resident software, an SRE module, a Noah module, an imputed inverse transform module and an optimization module.

Referring to the Figures, speech material consisting of nonsense sentences or un-related words from a word list that are very rich in frequency content and replete with time and amplitude variations is stored in the memory of the computer system 10. The stored speech material is presented aurally by the computer system

4

10 by means of a speaker 12 to the hearing impaired individual wearing an electronically adjustable hearing aid 14. The hearing aid 14 is connected to the computer system 10 by a cable, or some form of wireless data transfer. The individual identifies the words that are heard by repeating them back into the
5   computer system 10 via a microphone 16 (Fig. 2), which then compares this input to original speech material and lists the incorrect words in an error file in the computer system 10.

As illustrated in Figures 3 and 4, by considering the incorrectly identified words and using pre-knowledge of their frequency content and their time and
10   amplitude variations, the computer system 10 calculates an imputed inverse transform for a digital (DSP) aid and guides the adjustable parameters within the imputed inverse transform in a programmable DSP aid in an optimization routine to reduce the error list to a minimum through repeated trials. The computer system 10 can also adjust the parameters in a fixed program DSP aid or an analog
15   aid in an optimization routine to reduce the error list to a minimum through repeated trials.

Since the optimization routine is based on mathematical concepts, such as the Simplex algorithm or those used in multi-dimensional servo control systems, the fitting is highly time efficient, accurate and independent of the experience of the
20   dispenser. A further benefit is that the fitting is completely automatic, leading to lower hearing aid distribution cost.

To facilitate the automation, the hearing impaired subject repeats the speech material into the microphone 16 connected to the SRE module, a voice/speech recognition engine that is a part of the computer system 10. Keyboard entry or
25   touch screens might also be used to enter the subject's repeated speech material into the computer system 10, but many subjects are not skilled with this form of data entry. Another party, such as the dispenser, could enter data, but this would not be automated and would not lower the cost of dispensing.

5

While the specific embodiment has been illustrated and described, numerous modifications come to mind without significantly departing from the spirit of the invention and the scope of protection is only limited by the scope of the accompanying Claim.

CLAIMS

What I claim is:

1. A method of optimizing hearing aid adjustments comprising:

   providing a computer;

   providing speech material consisting of nonsense sentences or un-related words from a word list, said words being rich in frequency content and replete with time and amplitude variations;

   presenting said speech material aurally to a hearing impaired individual wearing an electronically adjustable hearing aid;

   repeating the words;

   comparing the repeated words to the original speech material and identifying the incorrect words in an error file;

   considering the incorrectly identified words using pre-knowledge of their frequency content and their time and amplitude variations; and

   calculating an imputed inverse transform for a digital (DSP) aid.

2. A system for optimizing hearing aid adjustments comprising:

   a computer system having a memory;

   speech material stored in said computer memory, said speech material consisting of nonsense sentences or un-related words from a word list, said words being rich in frequency content and replete with time and amplitude variations;

   said computer system including means for presenting said stored speech material aurally to a hearing impaired individual wearing an electronically adjustable hearing aid, means for receiving the words repeated by said individual, means for comparing the repeated words to the original speech material and identifying the incorrect words in an error file; means for considering the incorrectly identified words using pre-knowledge of their frequency content and

their time and amplitude variations; and means for calculating an imputed inverse transform for a digital (DSP) aid.
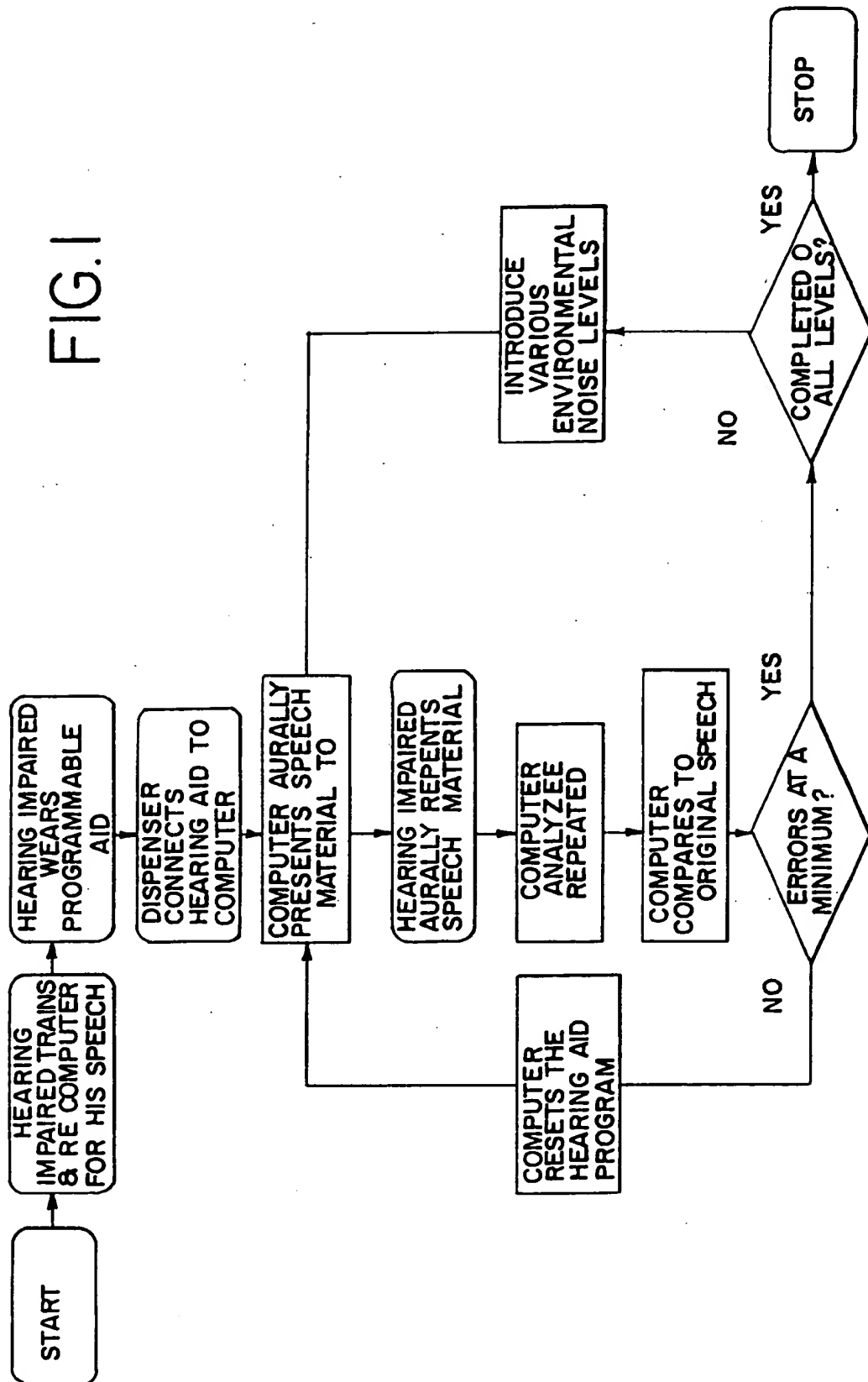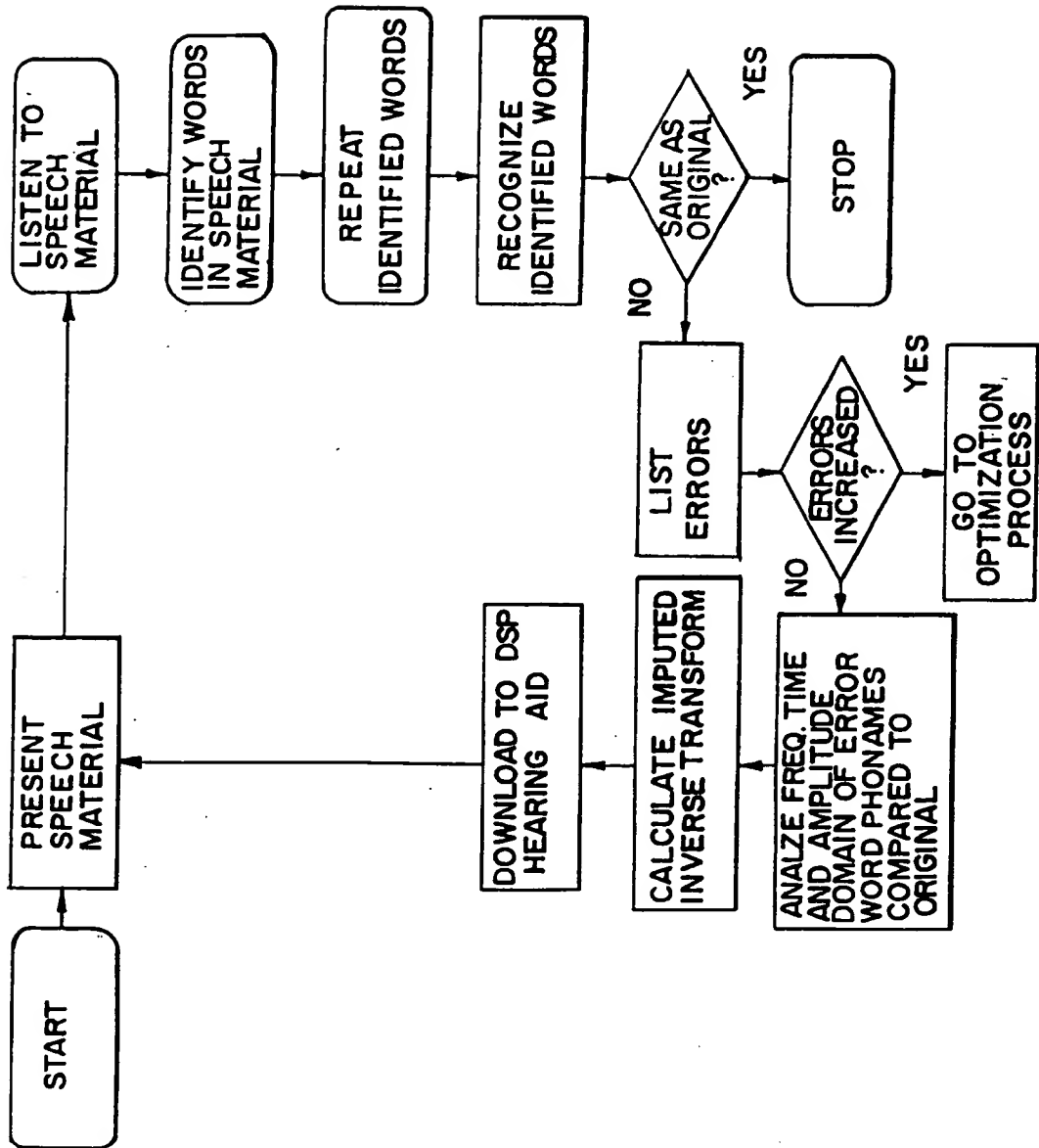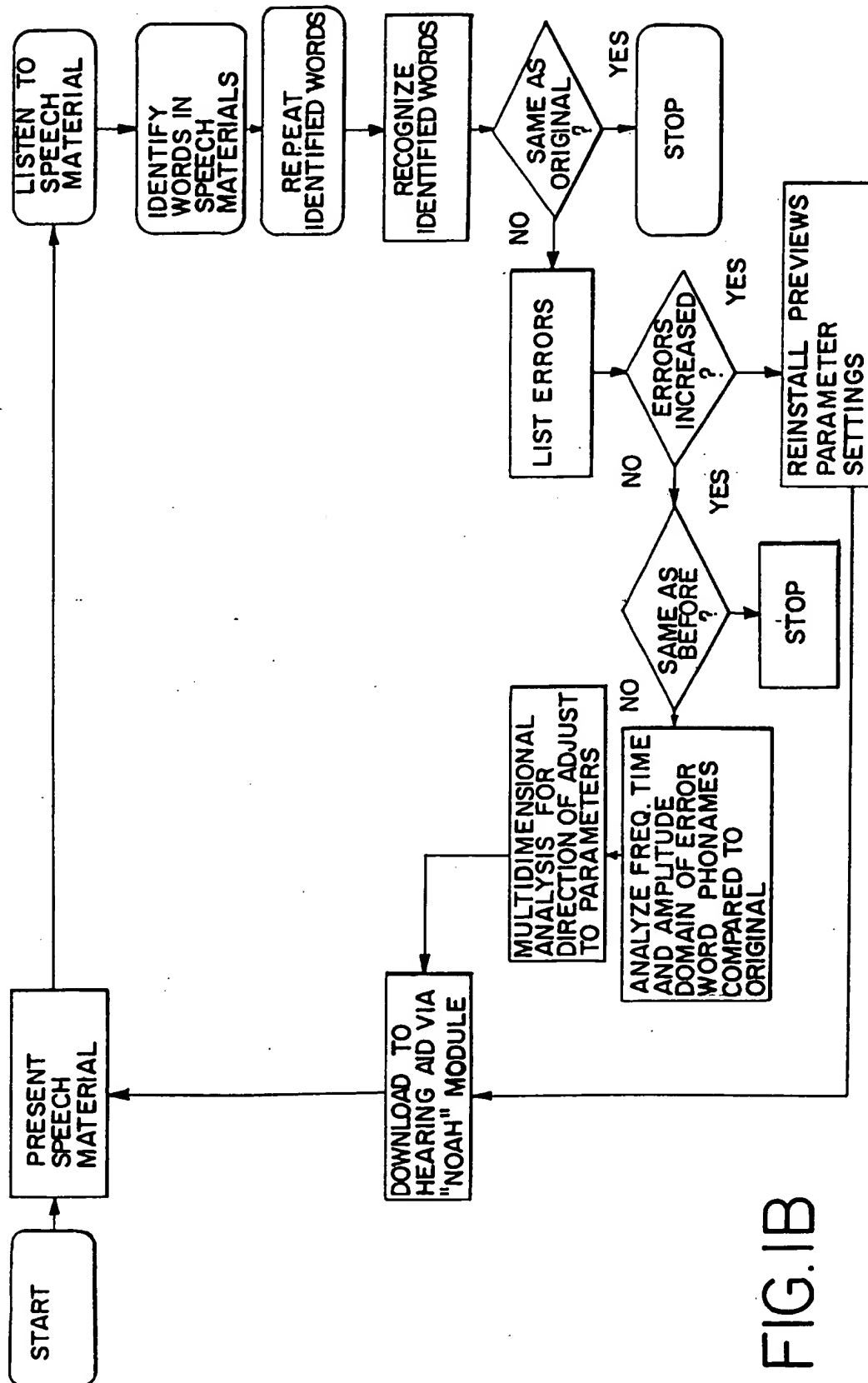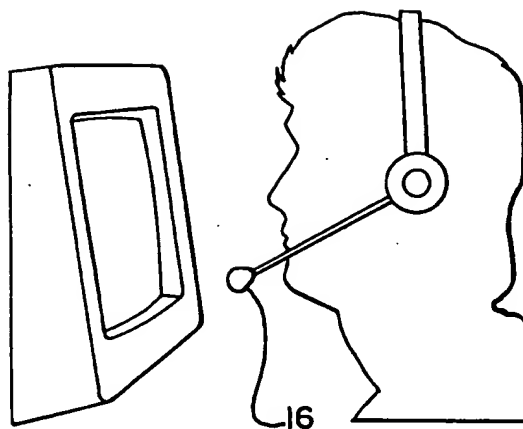
FIG.1

FIG. IA

FIG.IB

FIG.2

FIG. 3

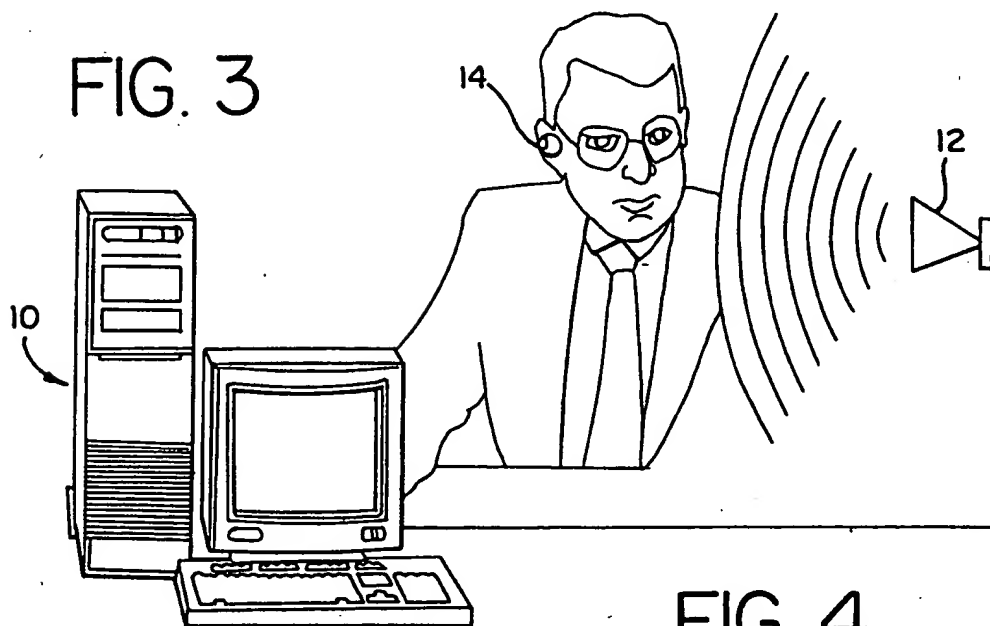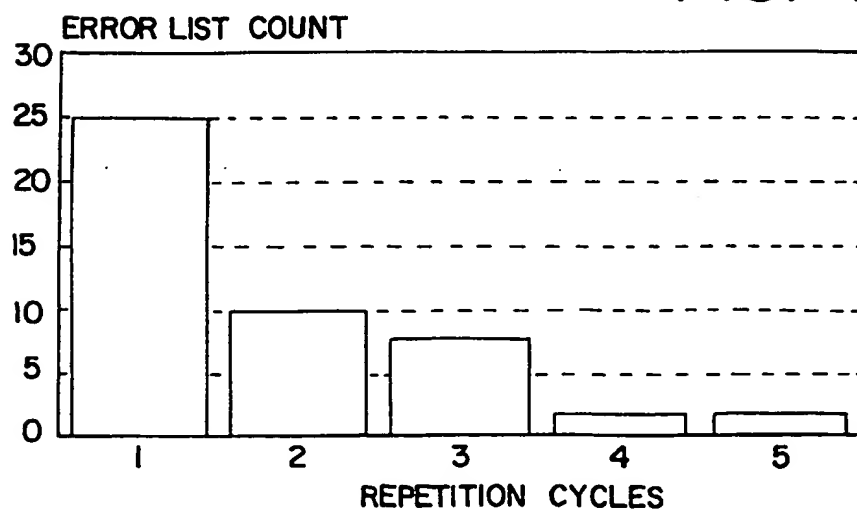

FIG. 4

ERROR LIST COUNT

REPETITION CYCLES

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US98/25950

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6)   :H04R 29/00

US CL   :381/60

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. :   381/60, 312; 73/570

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS, DERWIN WPIDS

search terms: repeat, recite, words, sentence, pronounciation, hearing, aurally

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 3009204 A (MAAS) 24 September 1981, see english abstract.	1-2
Y	EP 360909 A (LIEBSCHER) 04 April 1990, see english abstract.	1-2

☐ Further documents are listed in the continuation of Box C.   ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	
"E"	earlier document published on or after the international filing date	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	
		"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means	
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
22 FEBRUARY 1999	2 9 MAR 1999

Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	Authorized officer PING LEE *James R. Matthews*
Facsimile No. (703) 305-3230	Telephone No. (703)305-3900

Form PCT/ISA/210 (second sheet)(July 1992)*